DOI:
10.1097/j.pain.0000000000001203

Document Version
Peer reviewed version

PAIN Publish Ahead of Print
DOI: 10.1097/j.pain.0000000000001203

Title page:

The burden of orofacial pain in a socially deprived and culturally diverse area of the United Kingdom

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Number of pages: 33.
Number of figures: 1.
Number of tables: 4.

Abstract

Little is known about the burden and impact of orofacial pain in deprived areas, and whether it mediates the relationship between socio-economic position (SEP) and impacts on daily life. We analysed data from a representative sample of 2,168 adults, aged 16-65 years, from the East London Oral Health Inequality study. Participants completed a validated questionnaire on demographics, SEP (area deprivation), orofacial pain (by anatomical site) in the past month and impacts related to oral conditions on daily life. Negative binomial regression models with robust variance estimator were fitted. The prevalence of orofacial pain was high (30.2%). The most common subset of orofacial pain was intraoral pain (27.5%). The prevalence of pain related to temporomandibular disorders (TMD) was 6.8%. The most common subsets of intraoral pain were tooth (20.4%) and gingival (11.4%) pain. Orofacial pain, its subsets (intraoral and TMD-related pain), and intraoral pain subsets (tooth and gingival pain) consistently showed associations with all dimensions of impacts on daily life that were highly statistically significant: functional limitation, psychological discomfort, disabilities and handicap. Socio-economic inequalities were present in orofacial pain and some dimensions of impacts on daily life. Orofacial pain did not mediate the relationship between area deprivation and impacts on daily life. Our study demonstrated a substantial burden and impact of orofacial pain in a socially deprived and culturally diverse area of the UK. To address this burden, interventions that lie within the remit of health services are needed to improve access to dental care for adults with orofacial pain.

Key words: Epidemiology; orofacial pain; health-related quality of life; social determinants of health; area deprivation; adult; mediation analyses.

Introduction

The number of people with untreated oral conditions reached 3.5 billion (age-standardised prevalence: 48%) in 2015. Untreated caries in permanent teeth and severe periodontal disease affected 2.5 billion and 538 million people respectively (age-standardised prevalence: 34.1% and 7.4% respectively) [16].

A major biological consequence of untreated oral conditions is pain. Data derived from adult national surveys show that 12-month prevalence of oral pain ranges from 8% to 40.4% [39,42]; and the six- and 12-month prevalence of dental pain ranges from 14% to 14.5% [18,46] and from 15.2% to 27% [26,43] respectively. Most population-based studies measured dental pain as 'tooth' pain only, without the explicit inclusion of 'gingival' pain in the measurement tool. The available estimate of gingival pain is confined to the six-month prevalence of gingival abscess, which is reported to be 10% [1]. Orofacial pain and pain associated with temporomandibular disorders (TMD) have rarely been included in national surveys. Relevant data are largely found in regional/community population-based surveys. The estimates of one-month prevalence of orofacial pain ranged between 26% and 41.6% and jaw joint pain ranged between 5.7% and 14% [23,25]. The estimates (including lifetime prevalence) of TMD-related pain (jaw joints and muscles pain) ranged between 3% and 62% [24]. There is a paucity of epidemiological data on the prevalence of tongue, cheek, palate and floor of mouth pain.

Orofacial pain leads to functional limitations, psychological and social disabilities in individuals (e.g. difficulties in eating, sleeping, relaxing, performing well at work and keeping in a 'good mood') [1,6-9,13,14,20,28,34,47]. On average, those who experienced oral pain were twelve times more likely to report disability days (days spent in bed or days in which normal activity was restricted) compared with their oral pain-free counterparts [36].

Despite the significant impact of orofacial pain on quality of life, oral epidemiology has focussed on reporting the prevalence and impact of oral diseases and only a few studies have included a measure of pain. The latter was either pain related to a single oral disease or different combinations of pain related to oral conditions.

The dental literature has demonstrated socio-economic inequalities in pain caused by untreated oral conditions [2,32,42,46]. A significant gradient by area-level socio-economic position (SEP) has been demonstrated, with those living in the richest areas reporting the lowest pain prevalence [2].

Based on the World Health Organization's theoretical framework of "impairments, disabilities and handicaps" [49] and "functioning and disability" [50], area deprivation might lead to experiencing orofacial pain, which in turn might lead to functional limitations, disabilities and handicaps (Fig. 1).

This study aimed to assess: (i) the prevalence of orofacial pain in total as well as by subset and anatomical site (tooth, gingiva, cheek, jaw, jaw joint, tongue, palate and/or floor of mouth) (ii) socio-economic inequalities in orofacial pain and related subsets, and (iii) their impacts on daily life in the inhabitants of a socially deprived and culturally diverse area of the United Kingdom. Additionally, we hypothesised that orofacial pain mediates the association between area deprivation and oral impacts on daily life.

Methods

The present study is part of the East London Oral Health Inequality (ELOHI) study, which included a representative sample of adults aged 16-65 years (n=2,343) living in the three outer-metropolitan boroughs of Barking and Dagenham, Redbridge and Waltham Forest in 2009-10. The Outer North East London Research Ethics Committee approved the study

protocol (REC Reference Number: 08/H0701/93), in accordance with the Declaration of the World Medical Association. Informed written consent was obtained from participants.

The ELOHI study adopted a cross-sectional design. A multi-stage stratified random sampling approach was used to select a representative sample of the general non-institutionalised population. The sampling frame was a list of all addresses stratified by the number of wards in Barking and Dagenham (n=17), Redbridge (n=21) and Waltham Forest (n=20) in outer East London. Fifty-five addresses were randomly selected from each ward to yield 3,193 addresses in total for the area. Residents were then contacted by post and invited to participate in the study. Non-respondents were visited to ascertain the age of residents and whether the household was empty. Four hundred and fifty-seven commercial premises or vacant addresses and 208 ineligible households with no residing adults aged 16 to 65 years were excluded. The final sampling frame included 2,528 valid addresses and 1,437 households agreed to participate in the study. The household response rate in Barking and Dagenham, Redbridge and Waltham Forest was 61%, 52.2% and 61.2% respectively, which represented a total response rate of 57%. Non-respondent households were replaced by inviting residents in the same postcode area to take part in the study. Up to two adults per household were invited to participate and all agreed, yielding a sample of 2,343 adults.

The minimum sample size to report the prevalence of orofacial pain with a 95% confidence interval (CI) and 2% standard error (assuming a population prevalence of 50%, design effect of 1.2 and 58 clusters (wards)) was estimated to be 754 participants with a minimum of 13 participants in each cluster. The minimum sample size to provide 80% statistical power to identify an odds ratio of 1.5 and/or a prevalence ratio of 1.2 was estimated to be 822. The calculation assumed that: 50% of the unexposed population and 60% of the exposed population have the outcome of interest, α is equal to 0.05, and β is equal to 0.20.

Participants answered a self-completed questionnaire supervised by field researchers who collected the ELOHI data at participants' own homes. This included questions on socio-demographic factors (sex, age, ethnicity and SEP). The area-level of SEP was measured using the 2007 English Index of Multiple Deprivation (IMD). The latter is a measure of deprivation calculated at a local area level by combining 38 measures from seven domains covering economic, social, health and housing characteristics [11]. Postcode data were used to obtain the 2007 English IMD scores, ranks and quintiles. The 2007 English IMD ranks range from 1 (the most deprived) to 32,482 (the least deprived area). With respect to related quintiles, the 1st quintile indicates that the local area falls among the most deprived 20% of local areas in England, while the 5th quintile indicates that the local area falls among the least deprived 20% of local areas in England.

Orofacial pain was measured using a question that assessed the experience of pain across different anatomical sites. Participants were asked whether they had experienced pain in the previous month in any of the following locations: tooth/teeth, gingiva, cheek, jaw, jaw joint, tongue, palate and/or floor of mouth. They were instructed to tick all answers that applied. Every answer was scored either 1 (indicating the experience of pain in the corresponding location in the last month) or 0 (indicating the absence of pain in the corresponding location in the last month).

The impact of oral conditions on daily life was measured using the Oral Health Impact Profile (OHIP-14) [40]. The latter includes seven dimensions: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and handicap. These dimensions capture outcomes that have a disruptive impact on individuals' lives. For example, the functional limitation and psychological discomfort questions capture impacts that would be apparent primarily to the individual [40], such as "Have you felt that your sense of taste has worsened because of problems with your teeth,

mouth or dentures?" (to capture functional limitation) and "Have you felt tense because of problems with your teeth, mouth or dentures?" (to capture psychological discomfort). The disabilities questions refer to impacts on every day activities, such as "Have you had to interrupt meals because of problems with your teeth, mouth or dentures?" (to capture physical disability), "Have you found it difficult to relax because of problems with your teeth, mouth or dentures?" (to capture psychological disability) and "Have you been a bit irritable with other people because of problems with your teeth, mouth or dentures?" (to capture social disability). The handicap questions capture the extent of disadvantage caused by poor oral health, such as "Have you felt that life in general was less satisfying because of problems with your teeth, mouth or dentures?". Each dimension is measured using two questions. The response for each question is made on a 5-point Likert scale ranging from never (score 0) to very often (score 4).

Data analysis

Data were analysed using IBM SPSS Statistics for Windows, version 24 (IBM Corp., Armonk, N.Y., USA). Cross–tabulations followed by negative binomial regression models with robust variance estimator were used to test associations, as all outcomes were common (>10%) binary variables. Therefore, we report prevalence ratios (PR) as the measure of association. The level of significance for all analyses was set at $P<0.05$.

The ELOHI data were weighted to adjust for the unequal probability of selection and non-response to produce a representative sample with respect to sex, age and ethnicity based on the UK Census [5]. Weighting the data did not increase the size of the sample (non-weighted sample=2,343 adults; weighted data=2,266 adults). We further excluded 98 cases due to incompleteness of data in reporting orofacial pain and oral impacts on daily life. Therefore, the weighted data analyses involved 2,168 adults.

In the present sample, the 2007 IMD ranks were grouped into quintiles based on the rank values that were used to generate the 2007 IMD ranks' quintiles for England. The frequency distribution of IMD quintiles in the present sample suggested collapsing the original groups into a smaller number of groups. Only 2.7% and 8.7% of inhabitants respectively lived in areas corresponding to the two least deprived quintiles of IMD ranks in England. A further 19.2% lived in the intermediate quintile; and the majority lived in the 4th and 5th most deprived quintiles (42.1% and 27.3% respectively). Therefore, we dichotomised the IMD quintiles' variable into least (30.6%) and most (69.4%) deprived quintiles.

The prevalence of pain was calculated as the presence of pain in each of the following anatomical sites separately: tooth, gingiva, cheek, jaw, jaw joint, tongue, palate and floor of mouth. Also, anatomical sites were grouped together to reflect intraoral pain (pain in the tooth, gingiva, tongue, palate and/or floor of mouth) and TMD-related pain (pain in the cheek, jaw and/or jaw joint). Additionally, both intraoral and TMD-related pain were grouped together to reflect orofacial pain. The aforementioned grouping approach was based on the classification of orofacial pain categories by the AAOP (the American Academy of Orofacial Pain) [10].

The scores of each OHIP-14 dimension, except physical pain, were calculated (scores ranged between 0 and 8, where the higher the score the higher the impact of oral conditions in that dimension). Thereafter, the scores were dichotomised into 'any impact' and 'no impact'. The latter implied the participant scored never (i.e. had a score of 0) in both of that dimension's questions. The aforementioned World Health Organization's theoretical framework of "impairments, disabilities and handicaps" [49] and "functioning and disability" [50] suggested that these aspects represent different dimensions; therefore, this study assessed the impact of pain on each dimension instead of adding all dimensions together.

To test the mediation hypothesis regarding the role of orofacial pain in explaining the relationship between SEP (area deprivation) and oral impacts on daily life, we broke down the total effect of area deprivation into two: the natural direct effect (i.e. the effect not mediated through orofacial pain) and the natural indirect effect (i.e. the effect mediated through orofacial pain) using the counterfactual-based approach to mediation analysis [45], as described by Lange et al. [17]. This approach has been used in the pain literature to test mediation hypotheses [e.g. 38]. To control for confounding variables (sex, age and ethnicity), we created inverse probability (IP) weights separately for the exposure (area deprivation) and mediator (orofacial pain).

First, the IP of exposure weight was calculated. This is the inverse of the predicted probability of the exposure conditional on observed covariates C (confounders). The purpose of weighting is to create a pseudo-population where the exposure is no longer associated with the confounders, by creating w_i copies of each subject i [37]. For example, a given subject with a weight of 4 contributes 4 copies of themselves to the pseudo-population. This in turn implies the IP of exposure controls for confounding by the set of covariates C used in constructing it. Furthermore, in small to moderate samples, the IP weights tend to be unstable as the weights can become so large that related individual observations dominate the estimation. Thus, weights are stabilised by substituting in the numerator of the IP weight the marginal probability of the exposure for the exposed and 1 minus this value for the unexposed. Therefore, the stabilised IP of exposure weight was calculated as:

$$w_i^x = \frac{P(X = xi)}{P(X = xi \mid C = ci)}$$

Here, x_i and c_i are the actual values of the exposure and covariates for subject i.

Next, the IP of mediator weight was calculated by constructing a new dataset by repeating each observation in the original data set twice and adding a new variable *xnew*,

which is equal to the actual exposure variable for the first replication and equal to the opposite of the actual exposure variable for the second replication.

Thereafter, the following mediator weight was calculated:

$$w_i^m = \frac{P\ (M = mi \mid X = xnewi, C = ci)}{P\ (M = mi \mid X = xi, C = ci)}$$

Whilst the numerator of the mediator weight corresponds to the indirect pathway using the probability of the mediator conditional on the *xnew* variable and covariates, the dominator corresponds to the direct pathway using the probability of the mediator conditional on the exposure and covariates.

The final weight was then created by multiplying the exposure weight by the mediator weight. Thereafter, we fitted inverse probability weighted negative binomial regression models with robust variance estimator to obtain prevalence ratios (PR) and 95% CIs for the direct and indirect effects. Only the exposure and new_i variables were included in these models. The coefficient of the exposure variable corresponds to the PR of the natural direct effect, while the coefficient of the new_i variable corresponds to the PR of the natural indirect effect.

Results

The mean age of the participants was 38.3 years (SD=13.3), and 48.2% were male. The majority of participants were from a White ethnic background (67.9%). The mean IMD scores in the sample and the population were 33.46 and 34.45 respectively, suggesting that the sample was representative of the local population.

The prevalence of orofacial pain and its subsets (intraoral and TMD-related pain) was 30.2% (95%CI: 28.3-32.1%), 27.5% (95%CI: 25.6-29.4%) and 6.8% (95%CI: 5.7-7.9%) respectively. The most common anatomical sites where pain was reported were the tooth (20.4%, 95%CI: 18.7-22.1%) and gingiva (11.4%, 95%CI: 10.1-12.7%). Pain in the cheek

(2.9%, 95%CI: 2.2-3.6), jaw joint (2.9%, 95%CI: 2.2-3.6), jaw (2.6%, 95%CI: 2.2-3.6), tongue (1.7%, 95%CI: 1.2-2.3), palate (1.2%, 95%CI: 0.8-1.7) and floor of mouth (0.8%, 95%CI: 0.4-1.2) was less frequently reported. Furthermore, 21.2% of participants reported pain in one anatomical site, while 6.3% reported pain in two anatomical sites. Small numbers of participants had pain in between three and seven anatomical sites (1.3%, 0.7%, 0.5%, 0.1%, and 0.1% respectively). None of the participants reported pain in all eight sites.

Orofacial pain was more prevalent in younger (16-24 years old) and older (55-65 years old) adults of working age; and less prevalent in 35-44-year-olds (Table 1). There were no significant differences in orofacial pain by sex or ethnicity. Orofacial pain subsets (intraoral and TMD-related pain) as well as intraoral pain subsets (tooth and gingival pain) were also more prevalent in the youngest and oldest adult participants, and the lowest prevalence was observed among participants aged between 35 and 44 years (Table 1). Female participants were significantly more likely to report intraoral pain and its tooth pain subset than their male counterparts. Whilst participants from a Mixed or other ethnic background were more likely to report intraoral pain and its subsets (tooth and gingival pain) compared with their White counterparts, Asian participants were less likely to report TMD-related pain compared with White participants.

Socio-economic inequalities amongst residents were identified in the prevalence of orofacial pain, its subsets (intraoral and TMD-related pain) as well as intraoral pain subsets (tooth and gingival pain) (Table 1). A total of 33.5% (95%CI: 31.5-35.5) of adults living in the most deprived neighbourhoods experienced orofacial pain compared with 22.6% (95%CI: 20.9-24.3) living in the least deprived areas, with all the aforementioned pain subsets showing similar trends (Table 1).

Multivariable regression modelling confirmed the significant impact of area deprivation on orofacial pain, its subsets (intraoral and TMD-related pain) and intraoral pain subsets

(tooth and gingival pain) (Table 2). PR adjusted by sex, age and ethnicity demonstrated that participants living in the most deprived areas were more likely to experience orofacial pain and the aforementioned pain subsets compared with their counterparts living in the least deprived areas (Table 2).

Table 3 summarises the prevalence of oral impacts on daily life by demographics, area deprivation, orofacial pain and its subsets (intraoral and TMD-related pain), and intraoral pain subsets (tooth and gingival pain). There were some significant sex, age and ethnicity variations in the prevalence of oral impacts, but not in all dimensions of the OHIP-14 measure. Oral impacts on daily life were generally more prevalent in male and older adults of working age. Asian adults were more likely to report physical disability, while they were less likely to report psychological discomfort compared with their White counterparts. Also, socio-economic inequalities were identified in four out of the six dimensions of oral impacts on daily life (Table 3). Participants living in the most deprived neighbourhoods were more likely to have functional limitation (PR 1.66, CI: 1.34-2.05), psychological discomfort (PR 1.20, CI: 1.06-1.37), psychological disability (PR 1.24, CI: 1.07-1.45) and handicap (PR 1.36, CI: 1.09-1.68) compared with their counterparts living in the least deprived areas of outer East London.

Orofacial pain, its subsets (intraoral and TMD-related pain), as well as intraoral pain subsets (tooth and gingival pain) consistently showed associations with all dimensions of oral impacts on daily life that were highly statistically significant (Table 3). Participants experiencing orofacial pain and the aforementioned pain subsets were two to four times more likely to have functional limitation, psychological discomfort, physical disability, psychological disability, social disability and handicap.

The results of mediation analyses demonstrated significant natural direct effects of area deprivation on functional limitation and handicap (Table 4). No significant natural indirect effects of area deprivation were observed in relation to any dimension of oral impacts on daily life (Table 4).

Discussion

Our study demonstrated a substantial burden and impact of orofacial pain, explored by anatomical site, in a socially deprived and culturally diverse area of the UK. Socio-economic inequalities in orofacial pain and some dimensions of oral impacts on daily life were present. Orofacial pain did not mediate the relationship between area deprivation and oral impacts on daily life.

We explored pain by anatomical site and reported the high prevalence of orofacial pain in this community. The epidemiology of orofacial pain has many weaknesses. Besides its paucity [24,33], the methodological validity and heterogeneity of relevant population-based studies, in terms of case definition, instruments and prevalence period, pose many limitations. Previous studies that estimated the one-month prevalence of orofacial pain included different components of oral and facial pain [21,26]. Therefore a direct estimates comparison is not possible. Keeping the aforementioned methodological heterogeneity in mind, our estimates of orofacial pain (30.2%) and its intraoral pain subset (27.5%) were higher than the UK local and national estimates of orofacial (26%) and oral pain (8%) [23,42], suggesting a substantial burden of such pain in outer East London. Similarly, our estimate of tooth pain (20.4%) was more than double the national estimate of current toothache (9%) [42], suggesting a substantial burden of this intraoral pain subset in outer East London. The prevalence of pain in the gingiva and other anatomical sites (with the exception of the jaw and jaw joint) in the past month has not been reported in the literature. Our estimates of jaw (2.6%) and jaw joint

pain (3%) were lower than that reported nationally (5.7%) [23], in Canada (8.9%) [20], Italy (5.1%) [28] and Hong Kong (14%) [25].

Our study also revealed slightly higher socio-economic inequalities in orofacial pain and the impacts of oral conditions on daily life within this socially deprived and culturally diverse population of the UK. Despite the small percentage of inhabitants being classified in the 1st and 2nd least deprived quintiles, the difference in the prevalence of orofacial pain between individuals living in the least (22.6%) and most deprived areas (33.5%) was 11%, which is slightly higher than the 6% difference in the prevalence of oral pain, reported nationally between managerial/professional households (26%) and routine/manual households (32%) [42]. In our study, differences in oral impacts on daily life between individuals living in the least and most deprived areas ranged between 2% and 9%. These differences are slightly higher than national differences, which ranged between 2% and 8% [30].

The high prevalence of reported orofacial pain amongst adults living in deprived areas may reflect a combination of more disease (e.g. untreated tooth decay and periodontal diseases) and access barriers hindering the receipt of appropriate dental care by these adults [46]. Dental diseases, and in particular tooth decay and periodontal diseases, correlate with the material and social features of deprived areas. These features limit accessibility to oral health-promoting opportunities, such as healthy food choices [15,29]; and undermine social capital, thereby generating mistrust, disorder, social exclusion and psychological stress [4]. In addition, there are well-documented contextual barriers in deprived areas to the use of dental services to relieve orofacial pain [2]. Such barriers are related to the availability, accessibility and accommodation of dental services in deprived neighbourhoods [7]. Also, area deprivation might reflect the effect of individual-level SEP characteristics (e.g. income), as more poor

people tend to live in deprived areas. Clearly the affordability of dental care is determined by individuals' income. Even when utilising public health services, such as the UK National Health Services (NHS), concerns about NHS dental charges present a major barrier for those on low incomes [41], if they are required to make co-payments. There is evidence nationally that socio-economically disadvantaged adults are more likely to delay NHS or private dental treatment because of cost [31]. In addition to affordability, there is also evidence that disadvantaged adults face other barriers such as dental anxiety and a poor patient-dentist relationship [3,22,31].

Our findings do not support the hypothesis that orofacial pain mediates the relationship between socio-economic inequalities and the impacts of oral conditions on daily life. The only natural direct effects of area deprivation found were on functional limitation and handicap. This suggests the presence of other potential mediators, such as tooth loss. Tooth loss was shown to have an impact on aspects of functional limitation, such as speaking problems [51].

The principal strength of this study is the rigorous analytic approach, using data from a representative sample of adults in outer East London boroughs. The ELOHI study's weights were used, and thus we are confident about our sample representativeness of the adult population in outer East London. Missing data in our study were unlikely to affect the generalisability of the findings to the study population. Although our study sample represents 95.7% of the adults who participated in the ELOHI study there were no differences in the socio-demographic composition between our sample and the total sample of ELOHI participants. Also, the SEP indicator used in our study, as opposed to income and social class, has a key methodological advantage: it is easy to collect and sometimes readily available to the vast majority of the population, leaving almost no individual without classification [19].

Using the counterfactual-based approach to mediation analysis is more robust compared with the stepped regression approach, as it allows the quantification of both direct and indirect pathways between the exposure and outcome of interest [17,37].

Despite these strengths, our study is not without limitations. The cross-sectional nature of our data limits the ability to establish causal relationship. Mediation could be assessed by more sophisticated methods such as structural equation modelling; however, we selected the counterfactual-based method that is appropriate to the cross-sectional nature of our data. The threshold that we adopted to dichotomise impact scores might have underestimated socio-economic inequalities in oral impacts on daily life. Higher thresholds might have shown larger socio-economic differences. A further limitation is the measurement bias, arising from the use of self-reported measures. Nonetheless, pain and oral impacts on daily life can only be measured by self-report.

The significance of our study is that it reveals the substantial burden and impact of orofacial pain in deprived areas. Addressing this burden requires interventions that lie to a considerable extent within the remit of health services. Taking into consideration that oral/orofacial pain relief is considered a priority for public funding [41], and based on principles of Universal Health Coverage [12] and the access model by Penchansky and Thomas [35], interventions should aim to increase the availability of an accessible service which should be ideally free-of-charge [48].

Conventional dental care might be too expensive to address the high prevalence of oral conditions leading to orofacial pain [16]. Minimal intervention dentistry (MID) may help address this public health challenge. MID is the modern medical approach to the management of caries, focusing on the interception of disease at an early stage. This includes the atraumatic restorative treatment technique, which uses hand instruments alone to remove

carious tooth substance and restores the cavity using glass ionomer cement (GIC), without injections or drilling. The same material (GIC) is used to seal any adjacent enamel fissures, preventing the development of new caries in the most vulnerable areas of the teeth. The MID approach reduces the cost of treatment dramatically and avoids undesirable and costly general anaesthesia as well as the need for sedation. Besides MID and taking into consideration that extraction alone might create long-term impacts on daily life, further research is recommended to explore the cost-effectiveness of other approaches to the management of orofacial pain.

Upgrading the material and social features of deprived areas might tackle the root causes of orofacial pain; however, evidence on the effectiveness of such interventions is still in its infancy and findings are inconsistent [44].

In conclusion, our study demonstrated that the prevalence of orofacial pain is high in a socially deprived and culturally diverse metropolitan area of the UK, with one in three people experiencing orofacial pain. Orofacial pain had significant impacts on daily life and was higher amongst adults living in the most deprived areas compared with their counterparts living in the least deprived areas. Orofacial pain did not mediate the relationship between area deprivation and oral impacts on daily life.

Acknowledgment

This research project was partially funded by Barking and Dagenham, Redbridge and Waltham Forest Community Services. The study was carried out by the Institute of Dentistry, Barts and The London School of Medicine and Dentistry, Queen Mary University of London (QMUL), in collaboration with Barking and Dagenham, Redbridge and Waltham Forest Primary Care Trusts (PCTs) to inform planning and commissioning of dental care services. We are grateful for the support of the families and individuals involved in this study. We also

thank individuals who helped organise and execute the ELOHI study (http://www.dentistry.qmul.ac.uk/research/Population%20Oral%20Health/Patient%20and%20Population%20Orien tated%20Research/oral-health-needs/ index.html). In addition, we thank Professor Tim Newton for commenting on an earlier version of this work. We declare no conflict of interest.

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Legends

Fig 1. The present study's theoretical framework.

Table 1. Prevalence of orofacial pain, its subsets and intraoral pain subsets by demographics and area deprivation (n= 2,168, East London).

Characteristics	N[1]	Orofacial pain[2]		Orofacial pain subsets							
				Intraoral pain[3]		TMD pain[4]		Intraoral pain subsets			
								Tooth pain		Gingival pain	
		%	PR[5] [95% CI]	%	PR [95% CI]	%	PR [95% CI]	%	PR [95% CI]	%	PR [95% CI]
Sex											
Men	1045	28.6	1.00 [Reference]	24.3	1.00 [Reference]	6.6	1.00 [Reference]	17.5	1.00 [Reference]	10.2	1.00 [Reference]
Women	1123	31.6	1.08 [0.95-1.24]	30.5	1.25 [1.08-1.44]**	7	1.06 [0.77-1.45]	23	1.34 [1.13-1.60]**	12.6	1.18 [0.92-1.51]
Age groups											
16-24 years	386	34.4	1.00 [Reference]	28.2	1.00 [Reference]	9.6	1.00 [Reference]	17.7	1.00 [Reference]	14.1	1.00 [Reference]
25-34 years	548	28.2	0.87 [0.71-1.06]	27	1.02 [0.82-1.27]	6.4	0.75 [0.47-1.17]	21	1.30 [0.98-1.71]	11.7	0.88 [0.62- 1.24]
35-44 years	522	24.5	0.71 [0.57-0.88]**	23	0.80 [0.63-1.02]	4.6	0.52 [0.31-0.87]*	16.6	0.94 [0.69-1.27]	9	0.61 [0.41-0.90]*
45-54 years	405	32.3	0.93 [0.76-1.14]	29.1	1.04 [0.83-1.30]	9.4	0.96 [0.62-1.49]	23.9	1.36 [1.02-1.80]*	11.5	0.78 [0.54-1.14]
55-65 years	307	35.1	1.04 [0.85-1.28]	33.2	1.20 [0.96-1.50]	4.9	0.58 [0.33-1.01]	24.5	1.41 [1.05-1.89]*	11.7	0.83 [0.56-1.23]
Ethnicity											
White	1470	30.7	1.00 [Reference]	27.3	1.00 [Reference]	8.1	1.00 [Reference]	20.6	1.00 [Reference]	11	1.00 [Reference]
Asian	427	28.1	0.94 [0.78-1.14]	27	1.01 [0.83-1.23]	3.7	0.46 [0.26-0.82]**	19	0.96 [0.76-1.23]	10.3	0.88 [0.61-1.27]
Black	202	27.7	0.97 [0.71-1.14]	26.7	1.02 [0.73-1.42]	4	0.50 [0.19-1.33]	18.8	1.00 [0.67-1.50]	13.4	1.30 [0.79-2.16]
Mixed/others	69	37.7	1.30 [0.95-1.74]	36.8	1.44 [1.06-1.96]*	8.7	0.89 [0.38-2.11]	29.4	1.57 [1.09-2.24]*	21.7	2.11 [1.34-3.32]**
Area deprivation											
Low[6]	665	22.6	1.00 [Reference]	21.7	1.00 [Reference]	4.2	1.00 [Reference]	17.5	1.00 [Reference]	7	1.00 [Reference]
High[7]	1503	33.5	1.55 [1.32-1.82]***	30.1	1.44 [1.22-1.71]***	8	1.93 [1.29-2.89]**	21.7	1.28 [1.06-1.56]*	13.4	2.00 [1.45-2.74]***

[1] Counts are weighted.
[2] Includes intraoral pain (pain in the tooth, gingiva, tongue, palate and/or floor of mouth) and temporomandibular disorders-related pain (pain in the cheek, jaw and/or jaw joint).
[3] Includes pain in the tooth, gingiva, tongue, palate and/or floor of mouth.
[4] Temporomandibular disorders-related pain, which includes pain in the cheek, jaw and/or jaw joint.
[5] Negative binomial regression models with robust variance estimator were fitted and prevalence ratios (PR) were reported.
[6] The 1st, 2nd and 3rd least deprived quintiles (based on the rank values that were used to generate the 2007 Index of Multiple Deprivation ranks' quintiles for England).
[7] The 4th and 5th most deprived quintiles (based on the rank values that were used to generate the 2007 Index of Multiple Deprivation ranks' quintiles for England).
*P<0.05 **P<0.01 ***P<0.001

Table 2. Multivariable regression modelling for demographic and area deprivation differences in the prevalence of orofacial pain, its subsets and intraoral pain subsets (n= 2,168, East London).

Characteristics	Orofacial pain[1]	Orofacial pain subsets			
		Intraoral pain[2]	TMD pain[3]	Intraoral pain subsets	
				Tooth pain	Gingival pain
	PR[4] [95% CI]	PR [95% CI]	PR [95% CI]	PR [95% CI]	PR [95% CI]
Sex					
Men	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Women	1.05 [0.92-1.20]	1.24 [1.07-1.43]**	0.97 [0.71-1.32]	1.34 [1.13-1.60]**	1.13 [0.88-1.44]
Age groups					
16-24 years	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
25-34 years	0.87 [0.72-1.06]	1.05 [0.85-1.31]	0.67 [0.42-1.06]	1.34 [1.03-1.76]*	0.89 [0.63-1.26]
35-44 years	0.74 [0.59-0.92]**	0.86 [0.68-1.09]	0.47 [0.28-0.80]**	1.00 [0.74-1.36]	0.66 [0.44-0.98]*
45-54 years	0.97 [0.79-1.18]	1.09 [0.87-1.36]	0.90 [0.58-1.39]	1.43 [1.09-1.88]*	0.84 [0.58-1.23]
55-65 years	1.15 [0.93-1.41]	1.35 [1.07-1.69]*	0.57 [0.32-0.99]*	1.56 [1.16-2.08]**	0.98 [0.65-1.45]
Ethnicity					
White	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Asian	0.95 [0.78-1.15]	1.07 [0.88-1.31]	0.42 [0.23-0.76]**	1.07 [0.83-1.37]	0.89 [0.61-1.29]
Black	0.95 [0.69-1.31]	1.03 [0.73-1.45]	0.48 [0.18-1.32]	1.07 [0.70-1.63]	1.27 [0.76-2.12]
Mixed/others	1.28 [0.95-1.72]	1.45 [1.08-1.95]*	0.82 [0.34-1.95]	1.60 [1.13-2.26]**	1.98 [1.28-3.08]**
Area deprivation					
Low[5]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
High[6]	1.55 [1.32-1.83]***	1.45 [1.22-1.72]***	1.79 [1.19-2.71]**	1.29 [1.06-1.57]*	1.94 [1.41-2.66]***

[1] Includes intraoral pain (pain in the tooth, gingiva, tongue, palate and/or floor of mouth) and temporomandibular disorders-related pain (pain in the cheek, jaw and/or jaw joint).
[2] Includes pain in the tooth, gingiva, tongue, palate and/or floor of mouth.
[3] Temporomandibular disorders-related pain, which includes pain in the cheek, jaw and/or jaw joint.
[4] Negative binomial regression models with robust variance estimator were fitted and prevalence ratios (PR) were reported.
[5] The 1st, 2nd and 3rd least deprived quintiles (based on the rank values that were used to generate the 2007 Index of Multiple Deprivation ranks' quintiles for England).
[6] The 4th and 5th most deprived quintiles (based on the rank values that were used to generate the 2007 Index of Multiple Deprivation ranks' quintiles for England).
*P<0.05 **P<0.01 ***P<0.001

Table 3. Prevalence of oral impacts on daily life by demographics, area deprivation, orofacial pain and its subsets, and intraoral pain subsets (n= 2,168, East London).

Characteristics	N[1]	Functional limitation		Psychological discomfort		Physical disability	
		%	PR[2] [95% CI]	%	PR [95% CI]	%	PR [95% CI]
Sex							
Men	1045	21.1	1.00 [Reference]	39	1.00 [Reference]	24.4	1.00 [Reference]
Women	1123	18.6	0.91 [0.76-1.08]	34.1	0.89 [0.79-1.00]*	22	0.88 [0.75-1.03]
Age groups							
16-24 years	386	21.9	1.00 [Reference]	31.4	1.00 [Reference]	25	1.00 [Reference]
25-34 years	548	18.4	0.86 [0.66-1.12]	36.9	1.24 [1.03-1.49]*	22.2	0.93 [0.73- 1.18]
35-44 years	522	13.7	0.64 [0.48-0.86]**	34.6	1.14 [0.94-1.38]	18.7	0.80 [0.62-1.03]
45-54 years	405	25.3	1.14 [0.89-1.47]	39.9	1.29 [1.06-1.56]*	26	1.05 [0.83-1.34]
55-65 years	307	23.1	1.01 [0.76-1.33]	40.8	1.30 [1.07-1.59]**	26.2	1.04 [0.80-1.35]
Ethnicity							
White	1470	21.1	1.00 [Reference]	39.3	1.00 [Reference]	23	1.00 [Reference]
Asian	427	17.6	0.89 [0.70-1.15]	30.9	0.82 [0.69-0.98]*	25.8	1.28 [1.06-1.56]*
Black	202	12.9	0.68 [0.42-1.12]	29.2	0.76 [0.56-1.04]	18.3	0.72 [0.45-1.13]
Mixed/others	68	27.9	1.39 [0.95-2.03]	32.4	0.89 [0.64-1.24]	23.2	1.08 [0.71-1.65]
Area deprivation							
Low[3]	665	13.8	1.00 [Reference]	32.8	1.00 [Reference]	21	1.00 [Reference]
High[4]	1503	22.5	1.66 [1.34-2.05]***	38.1	1.20 [1.06-1.37]**	24.1	1.14 [0.96-1.36]
Orofacial pain[5]							
No	1514	10.9	1.00 [Reference]	26.3	1.00 [Reference]	14.1	1.00 [Reference]
Yes	654	40.6	3.92 [3.28-4.68]***	60.1	2.22 [1.99-2.47]***	44.2	3.16 [2.70-3.70]***
Orofacial pain subsets: Intraoral pain[6]							
No	1571	11.5	1.00 [Reference]	26.8	1.00 [Reference]	14	1.00 [Reference]
Yes	597	41.9	3.78 [3.19-4.48]***	62	2.24 [2.01-2.49]***	47.2	3.36 [2.88-3.91]***
Orofacial pain subsets: TMD pain[7]							
No	2020	18.2	1.00 [Reference]	34.5	1.00 [Reference]	21.2	1.00 [Reference]
Yes	148	42.6	2.43 [1.98-2.98]***	63.5	1.79 [1.56-2.06]***	49.3	2.24 [1.86-2.71]***
Intraoral pain subsets: Tooth pain							
No	1726	14.5	1.00 [Reference]	29	1.00 [Reference]	15.7	1.00 [Reference]
Yes	442	40.5	2.83 [2.41-3.34]***	65.9	2.22 [2.01-2.46]***	52.4	3.41 [2.95-3.94]***
Intraoral pain subsets: Gingival pain							
No	1920	16	1.00 [Reference]	32.8	1.00 [Reference]	19.2	1.00 [Reference]
Yes	248	49.8	3.19 [2.72-3.76]***	64.7	1.95 [1.74-2.19]***	53.7	2.69 [2.31-3.14]***

[1] Counts are weighted.
[2] Negative binomial regression models with robust variance estimator were fitted and prevalence ratios (PR) were reported.
[3] The 1st, 2nd and 3rd least deprived quintiles (based on the rank values that were used to generate the 2007 Index of Multiple Deprivation ranks' quintiles for England).
[4] The 4th and 5th most deprived quintiles (based on the rank values that were used to generate the 2007 Index of Multiple Deprivation ranks' quintiles for England).
[5] Includes intraoral pain (pain in the tooth, gingiva, tongue, palate and/or floor of mouth) and temporomandibular disorders-related pain (pain in the cheek, jaw and/or jaw joint).
[6] Includes pain in the tooth, gingiva, tongue, palate and/or floor of mouth.
[7] Temporomandibular disorders-related pain, which includes pain in the cheek, jaw and/or jaw joint.
* P<0.05 **P<0.01 ***P<0.001

Table 3 (continued). Prevalence of oral impacts on daily life by demographics, area deprivation, orofacial pain and its subsets, and intraoral pain subsets (n= 2,168, East London).

Characteristics	N[1]	Psychological disability		Social disability		Handicap	
		%	PR[2] [95% CI]	%	PR [95% CI]	%	PR [95% CI]
Sex							
Men	1045	31.4	1.00 [Reference]	17.7	1.00 [Reference]	20.3	1.00 [Reference]
Women	1123	26.8	0.85 [0.75-0.98]*	15.7	0.88 [0.72-1.06]	15.8	0.78 [0.65-0.94]***
Age groups							
16-24 years	386	26.5	1.00 [Reference]	12	1.00 [Reference]	10.6	1.00 [Reference]
25-34 years	548	29.4	1.16 [0.94-1.45]	19.6	1.70 [1.22-2.36]**	18.3	1.88 [1.32- 2.67]***
35-44 years	522	26	1.05 [0.83-1.31]	13.5	1.29 [0.86-1.75]	16.9	1.81 [1.27-2.58]**
45-54 years	405	32.9	1.28 [1.03-1.59]*	20.5	1.71 [1.22-2.40]**	22	2.17 [1.53-3.08]***
55-65 years	307	31.4	1.20 [0.95-1.51]	17.7	1.45 [1.02-2.12]*	23	2.22 [1.55-3.19]***
Ethnicity							
White	1470	30.4	1.00 [Reference]	16.7	1.00 [Reference]	18.6	1.00 [Reference]
Asian	427	26.2	0.92 [0.76-1.11]	17.6	1.20 [0.93-1.54]	17.3	1.07 [0.84-1.37]
Black	202	26.2	1.08 [0.81-1.45]	14.9	1.00 [0.63-1.58]	15.3	1.00 [0.65-1.54]
Mixed/others	68	25	0.91 [0.62-1.35]	15.9	0.97 [0.56-1.69]	15.9	0.95 [0.56-1.60]
Area deprivation							
Low[3]	665	25.4	1.00 [Reference]	14.7	1.00 [Reference]	14.9	1.00 [Reference]
High[4]	1503	30.6	1.24 [1.07-1.45]**	17.5	1.21 [0.97-1.51]	19.3	1.36 [1.09-1.68]**
Orofacial pain[5]							
No	1514	19.5	1.00 [Reference]	10.3	1.00 [Reference]	10.9	1.00 [Reference]
Yes	654	50.9	2.57 [2.26-2.92]***	31.3	3.08 [2.54-3.73]***	34.4	3.18 [2.65-3.82]***
Orofacial pain subsets: Intraoral pain[6]							
No	1571	20.1	1.00 [Reference]	10.9	1.00 [Reference]	10.9	1.00 [Reference]
Yes	597	52.4	2.56 [2.26-2.91]***	31.8	2.95 [2.44-3.57]***	36.3	3.31 [2.77-3.96]***
Orofacial pain subsets: TMD pain[7]							
No	2020	27	1.00 [Reference]	14.9	1.00 [Reference]	16.7	1.00 [Reference]
Yes	148	56.8	2.05 [1.75-2.41]***	41.2	2.67 [2.13-3.35]***	34.5	1.96 [1.53-2.51]***
Intraoral pain subsets: Tooth pain							
No	1726	21.8	1.00 [Reference]	12.1	1.00 [Reference]	12.5	1.00 [Reference]
Yes	442	57.3	2.64 [2.33-2.98]***	34.3	2.89 [2.40-3.48]***	39.2	3.15 [2.65-3.74]***
Intraoral pain subsets: Gingival pain							
No	1920	25	1.00 [Reference]	13.7	1.00 [Reference]	14.8	1.00 [Reference]
Yes	248	60.2	2.37 [2.08-2.70]***	39.9	2.88 [2.36-3.50]***	42.1	2.77 [2.30-3.33]***

[1] Counts are weighted.
[2] Negative binomial regression models with robust variance estimator were fitted and prevalence ratios (PR) were reported.
[3] The 1st, 2nd and 3rd least deprived quintiles (based on the rank values that were used to generate the 2007 Index of Multiple Deprivation ranks' quintiles for England).
[4] The 4th and 5th most deprived quintiles (based on the rank values that were used to generate the 2007 Index of Multiple Deprivation ranks' quintiles for England).
[5] Includes intraoral pain (pain in the tooth, gingiva, tongue, palate and/or floor of mouth) and temporomandibular disorders-related pain (pain in the cheek, jaw and/or jaw joint).
[6] Includes pain in the tooth, gingiva, tongue, palate and/or floor of mouth.
[7] Temporomandibular disorders-related pain, which includes pain in the cheek, jaw and/or jaw joint.
* P<0.05 **P<0.01 ***P<0.001

Table 4. Mediation analyses to test the role of orofacial pain in explaining the association between area deprivation and oral impacts on daily life (n= 2,168, East London).

Characteristics	**Functional limitation**	**Psychological discomfort**	**Physical disability**
	PR[1] [95% CI]	PR [95% CI]	PR [95% CI]
Natural direct effect			
Low area deprivation[2]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
High area deprivation[3]	1.34 [1.15-1.60]***	1.07 [0.98-1.18]	0.99 [0.87-1.12]
Natural indirect effect			
Low area deprivation	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
High area deprivation	1.00 [0.88-1.13]	1.00 [0.92-1.09]	1.00 [0.89-1.12]
	Psychological disability	**Social disability**	**Handicap**
Natural direct effect			
Low area deprivation	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
High area deprivation	1.11 [0.99-1.10]	1.08 [0.92-1.27]	1.20 [1.03-1.41]*
Natural indirect effect			
Low area deprivation	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
High area deprivation	1.00 [0.91-1.10]	1.00 [0.87-1.15]	1.00 [0.88-1.14]

[1] Inverse probability weighted negative binomial regression models (adjusted for sex, age and ethnicity) with robust variance estimator were fitted and prevalence ratios (PR) were reported.
[2] The 1st, 2nd and 3rd least deprived quintiles (based on the rank values that were used to generate the 2007 Index of Multiple Deprivation ranks' quintiles for England).
[3] The 4th and 5th most deprived quintiles (based on the rank values that were used to generate the 2007 Index of Multiple Deprivation ranks' quintiles for England).
* P<0.05, ** P<0.01, *** P<0.001